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to tenderness in beef (1 or 2 muscles, depending on selection criteria) and dairy (< 5 of 21 muscles, depending on selection criteria). Muscle pH was influenced by fat thickness and carcass muscling in beef (9 and 10 muscles, respectively) muscles, while few dairy (1 or 2 depending on criteria) muscles exhibited a relationship with any selection criteria. All selection criteria had low relationships to expressible moisture in beef and dairy (< 5 of 21 muscles) muscles. Total collagen was most frequently affected by maturity in beef (4 of 21 muscles), while weight had the greatest influence on dairy (6 of 21 muscles) muscles. Fat thickness most often influenced total heme-iron content in beef (12 of 21 muscles) muscles, while all selection criteria had little effect on dairy (< 5 of 21 muscles) muscles. Carcass fatness was the most common carcass selection trait related to muscle fat (16 beef and 14 dairy muscles) and moisture (21 beef and 19

dairy muscles) content. Muscle ash content was seldom influenced by any selection criteria for beef and dairy (< 5 of 21 muscles depending on criteria) muscles.

This research was performed as a follow-up to the muscle profile research of chuck and round muscles from fed cattle (2001 Nebraska Beef Report, pp 99-103). Muscles from cow carcasses exhibited a larger expressible moisture value than did muscles from the fed cattle study, probably because of differences in methodologies. In this study ground samples were collected while in the previous study a whole muscle cube was used. Values for pH and Warner-Bratzler shear force were higher in cow muscles as compared with the previous study. Muscles from cow carcasses were shown to have lower L* and a* values indicating cow muscles were darker and less red than those from fed cattle. As expected, the cow muscles were leaner than those of fed cattle, indicated by

lower percentage fat. Variation in trait values were detected in both studies. As a general rule cow muscles exhibited higher variability than muscles from fed cattle for the majority of traits measured.

These data indicate a vast range of values of measured characteristics for both beef and dairy cow muscles. Of the four selection criteria, estimated 12th rib fat thickness influenced the most muscle characteristics, particularly percentage fat and moisture. However, in general there was a lack of significant effects by the carcass characteristics on muscle characteristics measured. This variation indicates muscles exist that can be better utilized as value added products to increase the value of cow carcasses.

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Quality Traits of Grain- and Grass-Fed Beef: A Review

Perry Brewer
Chris Calkins¹

Grass-fed beef is less tender and lower in flavor and acceptability than grain-fed beef.

Summary

Carcasses from grass-fed beef have lower fat thickness and lighter carcass weights, which increases the risk for cold shortening and reduces muscle proteolysis, both of which would reduce beef tenderness. A review of nine research papers indicates grass-fed beef is lower in tenderness (both from shear force and by taste panel), flavor and overall acceptability/desirability ratings.

Introduction

Recently, interest in production of grass-fed beef has increased. Proponents identify advantages of sustainability, low inputs, a more "natural" process than grain feeding, reduced use of antibiotics, leaner/healthier meat and better flavor. Opponents caution that increased production time, cost of production, seasonality of forage resources, absence of evidence demonstrating that forage finished beef is healthier, economic risk, and limited marketing potential do not support finishing cattle on grass. Although each of these points (and many others) merit a detailed discussion, this review focuses on the characteristics of the end product — beef for human consumption. The tenderness and flavor of beef finished under either system has been studied in the past and this brief review of the literature is intended to provide concrete information on this particular aspect of the issue.

Procedure

This review includes data from nine publications that compared grain-fed to grass-fed beef. There are a variety of treatments among papers and within each study. For clarity, only all-forage treatments were compared to grain feeding, except the 2000 paper by French et al. This particular publication compared a number of treatments containing forages with several that included concentrates so the means of all-forage treatments versus those containing concentrates are presented. Different taste panel rating scales were used in the studies so the data are presented as a percentage of the rating scale to facilitate direct comparisons among studies. Of course, this is not a complete list of the grain versus grass-fed beef literature. We have attempted to summarize papers where animal age appeared to be controlled and where grain feeding lasted 85 days or more.

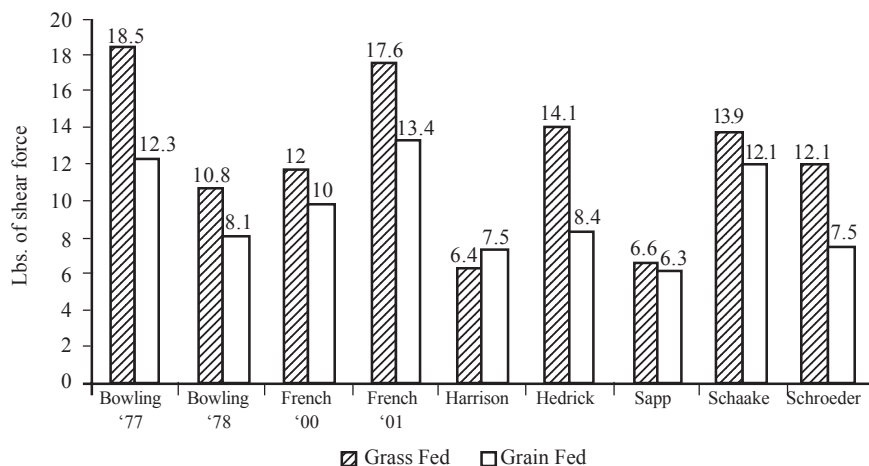


Figure 1. Warner-Bratzler shear force of grass- and grain-fed beef.

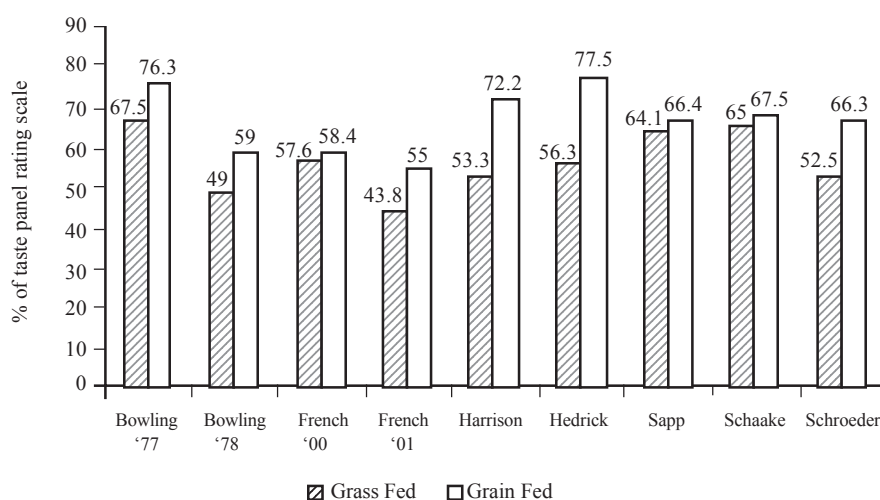


Figure 2. Taste panel tenderness ratings of grass- and grain-fed beef.

Results

Tenderness Issues

Figure 1 indicates a distinct advantage in tenderness (shear force) for grain-fed cattle versus grass-fed cattle. The only time the mean shear force for beef from grass-fed cattle was lower than for corresponding grain-fed cattle (in the Harrison et al., 1978 paper), the taste panel produced conflicting results (Figure 2). In that particular study, the taste panel ratings for tenderness were almost 2 full taste panel units lower (less tender) for the grass-fed treatment. Taken together, these data indicate that grass-fed cattle produce beef that is less tender than beef from grain-fed cattle.

Tenderness is one of the most important palatability traits influencing consumer satisfaction with beef. This

complex trait can be influenced by a number of factors. These factors may be categorized as those influencing connective tissue and those influencing the muscle fiber itself.

Muscles containing more connective tissue are less tender. Connective tissue from older animals is less heat soluble than connective tissue from younger animals. So both amount and solubility of connective tissue can influence tenderness. This can best be visualized by comparing a ribeye steak to a round steak from the same animal. The later has a much greater connective tissue content and of course is less tender. A steak from a mature animal is usually less tender than one from a younger animal because the connective tissue is less heat soluble. It's possible to detect differences in tenderness among animals that have been finished as calves

compared to those finished in yearling programs (see paper in this issue by Brewer et al.). Hence, anything that increases the time of production is likely to adversely affect tenderness.

A second aspect of connective tissue exists. Animals on a sub-optimal plane of nutrition frequently exhibit greater amounts of connective tissue. The hypothesis is that these animals have smaller muscle fibers. Given that each muscle fiber is covered with a layer of connective tissue, it's easy to understand that muscles with smaller fibers have proportionally more connective tissue. In effect, existing connective tissue is "diluted" by larger muscle fibers. As these fibers become smaller, the connective tissue becomes concentrated and exerts a greater influence on tenderness. This has been offered as an explanation as to why forage finished cattle have less tender meat.

Numerous factors influence the tenderness of the muscle fibers. Generally, they may be grouped into those that affect muscle fiber shortening and those that affect fragility of the muscle fibers. Implicitly, those muscles with longer fibers and those with more fragile fibers will be more tender.

A phenomenon of pre-rigor muscle is shortening in response to cold temperatures. Rapid chilling of beef carcasses, which occurs in carcasses with minimal subcutaneous fat, can increase muscle shortening. Carcasses with smaller muscle mass also chill more quickly and thus exhibit more muscle shortening. Although more gentle chilling conditions would minimize this condition, it is not recommended because of the benefits to food safety provided by rapid chilling of beef.

Fragility of the muscle fiber occurs as a result of post-mortem enzyme activity. Extended storage of beef under refrigerated conditions allows time for the natural, endogenous enzymes to function. This is the foundation of cooler aging and has been used for many years to enhance meat tenderness. More recent research clearly demonstrates that a significant increase in tenderization can occur during the hours immediately after harvest. The temperature of the meat

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Table 1. Carcass traits of grain and grass fed beef.

	Animal/ treatment	Carcass weight, lb		Fat thickness, in.		REA, in ²		KPH, %		YG		Marbling Score ^a	
		grass	grain	grass	grain	grass	grain	grass	grain	grass	grain	grass	grain
Bowling '77	30	483	476	.16	.33	9.5	11.0	2.3	3.5	2.1	2.4	8.9	9.4
Bowling '78	10	412	679	.06	.57	8.9	10.4	na	na	na	na	2.4	13.3
French '00	na												
French '01	na												
Harrison	8	573	728	.23	.26	10.3	12.1	2.7	3.3	2.7	3.3	9.5	15.4
Hedrick	27	346	646	.08	.43	7.5	10.9	1.8	2.3	1.8	3.0	5.9	13.9
Sapp	20	655	637	.32	.47	11.3	10.9	1.4	2.0	1.4	2.0	11.0	13.0
Schaaake	36	621	769	.20	.51	11.6	12.9	2.4	3.2	2.2	3.2	11.0	16.3
Schroeder	7	403	690	.10	.50	8.6	11.6	2.0	2.9	1.9	3.2	5.0	12.3

^aSmall + = 15, Small 0 = 14, Small - = 13 and so on.

during chilling not only influences shortening, described in the paragraph above, but also alters the extent of muscle proteolysis. More enzyme activity occurs at warmer temperatures. Thus, muscle chilled too quickly will be less tender not only because of cold shortening, but also because the lower temperature has minimized enzyme activity. Carcasses with more subcutaneous fat chill less quickly.

None of the studies reviewed made specific measures of muscle shortening, muscle fiber fragility, or connective tissue amount. However, almost every study revealed carcasses from grass-fed cattle to be lighter in weight, with less fat, smaller ribeye areas, and lower marbling scores than carcasses from grain-fed cattle. These conditions would be expected to allow greater muscle shortening and reduce proteolysis, together with possibly smaller muscle fibers (which would generate proportionally more connective tissue).

Flavor Issues

Flavor scores from trained taste panels support the contention that flavor of beef from grain-fed cattle is more desirable than beef from grass-fed steers (Figure 3). In the seven studies that included an assessment of overall acceptability/palatability, grain-fed beef was more highly rated every time.

Although some important flavor compounds in meat reside in the lean, compounds within the fat also contribute to the flavor profile — especially in the differences among species. Implicitly, the diet of the animal will influence these flavor contributors. Recent data reported in the *2001 Beef Cattle Report*, pp. 96-

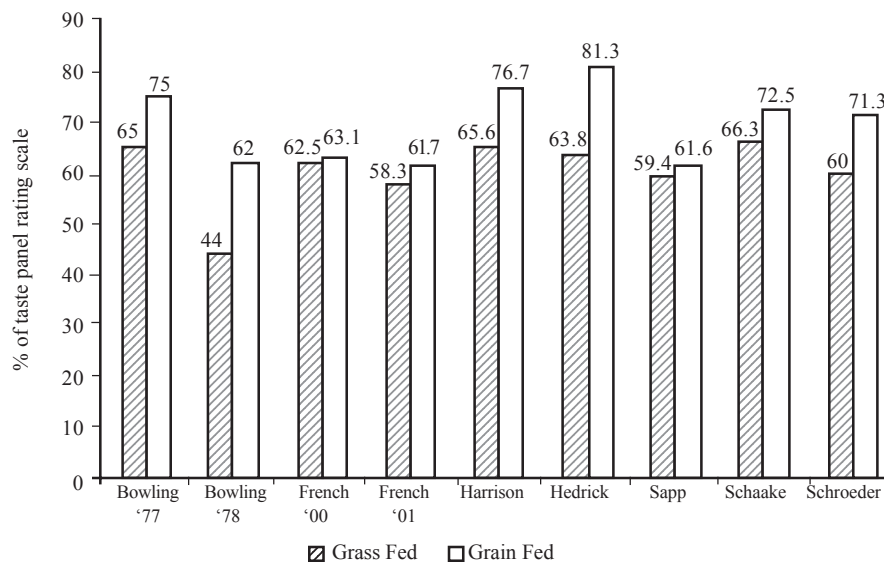


Figure 3. Taste panel flavor ratings of grass- and grain-fed beef.

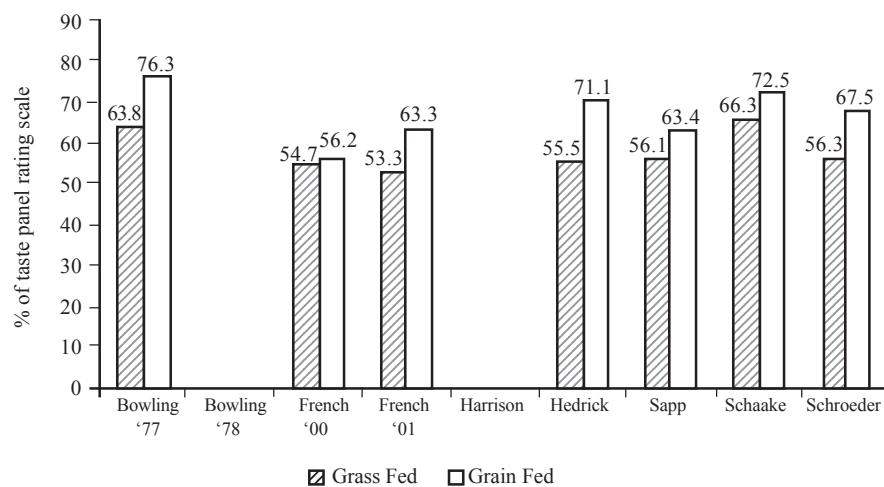


Figure 4. Taste panel overall acceptability/palatability ratings of grass- and grain-fed beef.

98, indicate there are significant flavor differences between grain-fed and grass-fed beef and U.S. consumers strongly discriminate against the flavor of grass-fed beef. This later research was conducted with beef loins matched

in tenderness, so there was no bias among the samples on the basis of texture. There were some differences in aging time between the grain-fed and grass-fed samples, but the longer aging period (which would be expected to

improve consumer acceptance of flavor) was for the grass-fed beef.

Although the preponderance of data indicate grass-fed beef is less desirable than grain-fed beef, a small niche market for grass-fed beef may exist. For those intent upon producing grass-fed beef, it would be imperative to identify a market for the meat before undertaking such a production system.

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The Effects of Tumbler Volume on Roasted Beef Quality

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Tumbling is a mechanical method of extracting myofibrillar protein and dispersing marinade throughout meat. One-third free space in the tumbler appears to be essential in achieving optimum quality.

Summary

Semitendinosus beef muscles ($n = 108$) were used to determine optimum tumbler volume with regards to meat quality. Fill capacity of 2/3 meat had lower shear force values than capacities of 1/2 ($P = 0.02$) and 1/3 ($P < 0.01$). Texture profile analysis showed favorable results among treatments. Hardness was lower with 2/3 capacity than 1/2 ($P = 0.02$) and 1/3 ($P = 0.06$). Gumminess favored 2/3 capacity over 1/2 ($P = 0.02$). Springiness favored 1/2 capacity over 1/3 capacity ($P < 0.01$) and 2/3 capacity ($P = 0.04$). Purge, absorption rate during tumbling, absorption rate after rest, cooking loss and yield had no effect between treatments.

Introduction

Value-added meats are becoming increasingly popular in today's marketplace. Low value and less desirable meats are improved in flavor, texture and consistency. This is accomplished with the use of marinades coupled with a mechanical action of massaging or tumbling. The ingredients of the marinades have well known effects. However, optimum times and volumes of the massaging method of tumbling are still unknown. The objective of this project was to study

the effects of the fill/free space in the tumbler to optimize flavor, texture and consistency of muscle. This will allow processors to understand the implications on textural properties as associated with tumbler fill capacity.

Procedure

Semitendinosus, NAMP 171C Beef Round, Eye of Round were purchased from ConAgra Meat Company and were delivered to the University of Nebraska Loeffel Meat Lab. Muscles were removed from the bag and fat and heavy external connective tissue was trimmed. Each muscle then was cut to a weight of 5.6 lbs. Muscles were sorted into three different batches. The first batch contained eight muscles, a second batch contained 12 muscles and a third batch contained 16 muscles. The study was replicated three times. Total batch weights were taken. A marinade was formulated containing 0.9 lb salt, 1.4 lb phosphates and 85.7 lb of water. This allowed for 0.25% salt and 0.40% phosphates in the meat. Using a hand-held stitch pump, muscles were pumped with the marinade to 115% green weight evenly throughout the batch. An additional 10% of the fresh meat weight was added directly into the tumbler. It was determined that the capacity of the tumbler was 39.6 gallons. Using water displacement, the amount of meat needed for each treatment was determined. To reduce the amount of meat needed to fill the tumbler to a desired capacity, dummy bags, approximating the meat weight were filled with 1 liter of water were used to achieve desired fill capacity since the density of water and meat are similar. Twenty bags were added to 8 *semitendinosus* to allow for 1/3 fill, 32 bags were added to 12 *semitendinosus* for 1/2 fill and 44

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